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THE SPINDLING-SPROUT DISEASE OF POTATOES.

F. C. STEWART AND F. A. SIRRINE.

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BULLETIN No. 399.

THE SPINDLING-SPROUT DISEASE OF POTATOES.[1]

F. C. STEWART AND F. A. SIRRINE.

SUMMARY.

The superiority of northern-grown over southern-grown seed potatoes is well known, but the explanation of it is not clear.

On Long Island, in the spring of 1914, there was much complaint of the poor condition of potato fields planted with home-grown seed. The stand was very uneven. There were many small, weak plants with very slender stems and, in some fields, many missing hills.

Upon investigation it was found that the weak plants and missing hills were, in most cases, the consequence of using, for seed, tubers which produce slender, thread-like sprouts. That is to say, the trouble was due to a weakened or debilitated condition of the seed tubers for which the writers propose the name spindling-sprout disease.

The cause of spindling-sprout is not definitely known though excessive heat and drought are suspected of being responsible for it. On Long Island, the weather in the summer of 1913 was very hot and dry. A similar disease, perhaps identical with spindling-sprout, occurs in parts of Europe, but plant pathologists are not agreed as to its cause.

Although, under exceptional conditions, spindling-sprout may occur as far north as Canada, it is chiefly a trouble of southern-grown seed. Hence the use of northern-grown seed is a means of avoiding it.

Long Island potato growers using home-grown seed should make a sprouting test of their seed potatoes. The appearance of spindling sprouts may be regarded as an indication that the seed is unfit for planting.

[1] A brief abstract of this paper was published in *Phytopath.* 4:395. Dec. 1914.

NORTHERN-GROWN VS. SOUTHERN-GROWN SEED.

Potato growers in the Southern States use large quantities of northern-grown seed. Their experience leads them to believe that better stands and larger yields are obtained from northern-grown than from southern-grown seed. Moreover, the results of numerous experiments in England and America indicate the superiority of northern-grown seed potatoes. It appears that, in some manner not fully understood, potatoes are debilitated by growing in a warm climate. Even as far north as Long Island the place of origin of seed potatoes is considered important. However, on Long Island, popular opinion on the subject is somewhat divided. While the prevailing opinion favors northern-grown seed it is a fact that large quantities of home-grown seed are planted every year. Some plant northern seed every other year and home-grown seed in the alternate years. Others follow the practise of planting each year a small quantity of northern seed to raise tubers with which to plant the principal part of their acreage the following year. Some use seed which has been grown on Long Island two or three years in succession.

In some seasons little fault is found with home-grown seed. In fact it happens, frequently, that home-grown seed gives better stands than northern-grown seed; but in other seasons there is much complaint about poor results from home-grown seed.

SPINDLING-SPROUT ON LONG ISLAND IN 1914.

During the season of 1914 such complaint was general. Almost every field planted with home-grown seed was in poor condition. There were many missing hills and the plants which grew varied much in size. Many plants were small and weak and had very slender stems. Some fields were in such poor condition that it was deemed advisable to plow them and replant the land with some other crop.

Upon making an inquiry into the cause of the trouble it was discovered that, in nearly every case, it was due, principally, to a weakness in the seed which we will call spindling-sprout disease. The following account of observations on an affected field near Riverhead will indicate the nature of the disease and the symptoms by which it may be recognized: The seed potatoes used in this

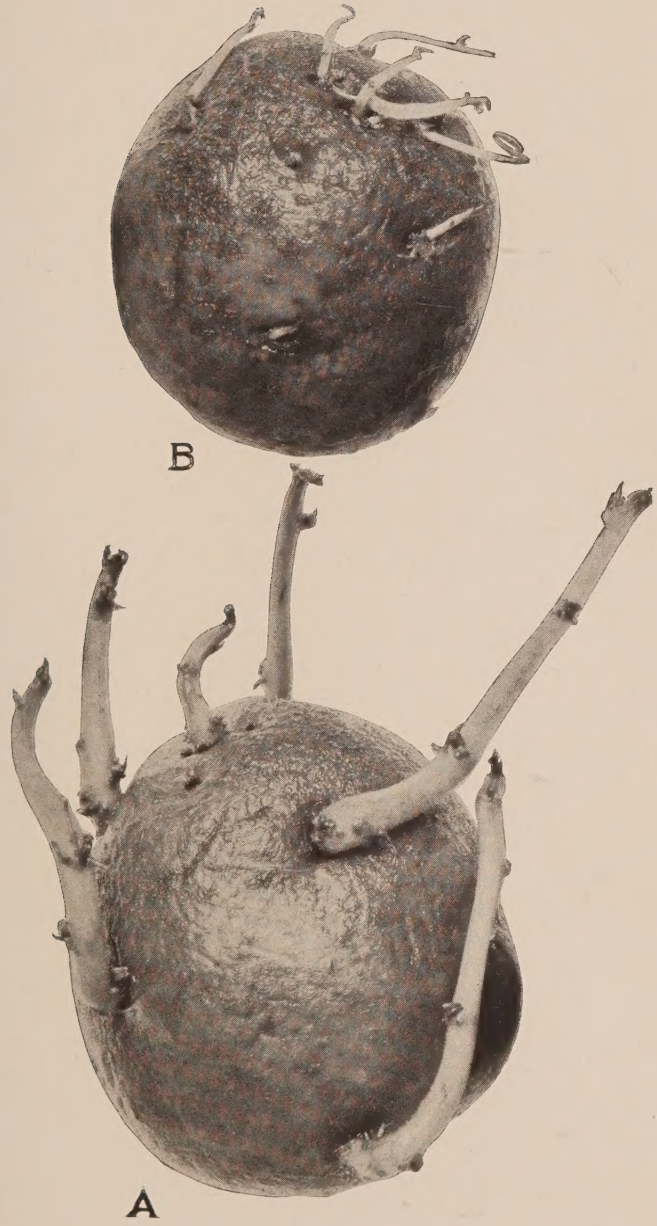

PLATE I.—SPINDLING-SPROUT DISEASE OF POTATO TUBERS.
A, normal; B, affected with spindling-sprout. (Natural size.)

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field belonged to the variety Green Mountain. They were grown on Long Island in the season of 1913 from Maine seed. The crop of that year was light owing to the unusually hot, dry weather, but, so far as observed, the plants showed no symptoms of spindling-sprout or other disease. During the winter of 1913–14 the potatoes were stored in crates in an unheated cellar where they appeared to keep well. At planting time in the spring of 1914 they were sound and plump and seemed to be in excellent condition except that they had sprouted to a considerable extent. At this time it was observed that some of the sprouts appeared weak, but little attention was given to the matter. During the handling incident to treatment with formaldehyde solution for scab most of the sprouts were destroyed. The tubers were afterwards cut and planted, April 24, about three inches deep with a Robbins potato planter. The soil was sandy loam thoroughly fitted and moist. Following planting the temperature and moisture conditions were favorable for the sprouting of potatoes.

Soon after the plants began to appear above ground it became evident that something was wrong. When some plants were six or seven inches high others were just breaking through the soil and there were, also, a good many blank spaces. It looked as if there would be a poor stand. Upon digging up the small plants it was found that they had very slender stems. Some seed pieces, though perfectly sound, had not started any sprouts. Others had put out sprouts which were so slender as to be scarcely recognizable as potato sprouts and too weak, apparently, to push their way through the soil. No lesions of any kind were found on the sprouts or stems and there was no rotting of the seed pieces. The trouble seemed to be due to some weakness of the seed.

Fortunately, several bushels of the uncut seed potatoes had been left over from planting. They had been stored in the cellar in crates. By this time they all bore sprouts from one to two inches in length. An examination of these tubers threw much light on the problem. While about two-thirds of the tubers bore normally robust sprouts the remainder bore exceedingly slender sprouts like those observed in the field. (See Plate I.) The contrast in appearance between tubers bearing the two kinds of sprouts was striking. All the sprouts on a tuber were stout or else all were very slender. Stout and slender sprouts did not occur on the same tuber and

tubers bearing sprouts intermediate in size were not common. In general, the sprouts were either of normal size or else very slender. Small, secondary tubers were of frequent occurrence on the slender sprouts. A careful examination failed to reveal any difference, other than the size of the sprouts, by means of which the weak tubers might be distinguished from the normal ones. There were no lesions of any kind and no discoloration either internally or externally. Tubers of all sizes were affected. In a cooking (boiling) test the two kinds of tubers appeared equal in quality.

These observations on the left-over tubers strengthened the suspicion that the trouble in the field was due to a weakness of the seed; but in order to definitely connect the spindling-sprouted tubers with the weak, slender-stemmed plants observed in the field, the following experiment was made: Twenty-five tubers with spindling sprouts and sixteen with normal sprouts were taken to Geneva and planted whole. Contrary to expectations every tuber produced a plant. All plants from the spindling-sprouted tubers were small, weak and slender-stemmed exactly like the plants observed in the field at Riverhead. Although in rich soil and given good cultivation and care, including thorough spraying with bordeaux mixture, the plants remained small to the end of the season. They showed no wilting, rolling, curling or spotting of the leaves, no lesions on the stems or other pathological symptoms. Neither did they die prematurely. They were simply small. The tubers produced were small but otherwise normal in appearance. The average yield per hill was only 8.6 ounces. Under similar conditions the normal-sprouted tubers, with one exception, produced strong, large plants which gave an average yield of 21.5 ounces per hill.

Returning, now, to the field at Riverhead: By the middle of June it was evident that the condition of the field was considerably better than our earlier observations had indicated. Estimates made at this time showed about 95 per ct. of a full stand with about 29 per ct. of the plants distinctly smaller than normal.

Similar observations were made in other fields. In one case a farmer called the writers' attention to the condition of his seed potatoes shortly before planting time. The potatoes were home-grown and of the variety Norcross. Being stored in a warm cellar they had commenced to sprout. Many were producing spindling sprouts. This caused the owner to suspect that the tubers were

weak and unfit for seed, but out of curiosity to see what they would do he planted a few bushels. The writers, also, planted about a bushel. Although a fair stand was obtained, over fifty per ct. of the plants in both cases were plainly below the normal in size, many being so small and weak that they were unable to produce any tubers of marketable size.

In previous years the writers have occasionally seen potato tubers which produced abnormally slender sprouts and more frequently heard of such cases. Also, they have observed on Long Island during the past twenty years a great many potato fields containing many small plants, the weak condition of which could not be accounted for satisfactorily; but it had never occurred to them that there was any relation between these two phenomena. However, an examination of the literature reveals the fact that this idea is not a new one.

SPINDLING-SPROUT, FILOSITÉ AND FADENBILDUNG.

Close and White[2] have described and illustrated spindling-sprout, pointed out its relation to weak plants in the field and shown that it is a factor in the low yields obtained from southern-grown seed. The spindling-sprout has been mentioned, also, by other American writers, but it has not received much attention.

It seems to have been spindling-sprout which Orton[3] had in mind when he wrote the following: "Premature ripening follows when potatoes bearing half-grown tubers are exposed to the midday heat of our Southern States. There is in addition to tipburn a yellowing and early death of the foliage. Potatoes produced in these southern conditions lose their constitutional vigor and germinate later, with small weak sprouts and give a smaller yield than seed from northern sources. This constitutional defect is not cured by restoration to a northern environment."

At the annual meeting of the New York Potato Association held in Ithaca last February, Prof. W. T. Macoun of Ottawa, Canada, stated positively that he has observed spindling-sprout at Ottawa among potatoes grown on light, sandy soil in the very dry season of 1905.

[2] Close, C. P., and White, T. H. Irish potato investigations. Md. Sta. Bul. 132. 1909.

[3] Orton, W. A. Environmental influences in the pathology of *Solanum tuberosum*. *Journ. Wash. Acad. Sci.* 3:184. 1913.

The writers have seen one quite bad case of spindling-sprout among potatoes which were said to have been grown in Maine and potato growers have reported its occasional occurrence at several different points in New York. Hence it appears that spindling-sprout is not strictly confined to southern latitudes.

The cause of spindling-sprout is not definitely known; though hot, dry weather is suspected of being, in some way, responsible for it. On Long Island the summer of 1913 was an exceedingly hot and dry one.

In Europe there is a potato disease which is called by the French "filosité" and by the Germans "Fadenbildung" and "Fadenkrankheit." Some of its symptoms (spindling, thread-like sprouts) are very much like those which characterize spindling-sprout.[4] Although it remains yet to be determined whether this disease is the same as spindling-sprout it is interesting to compare the opinions of plant pathologists concerning its cause.

Appel[5] states that in the spring of 1912 potatoes in parts of Germany came up poorly with numerous weak shoots. He uses no name for the disease, but his description and illustration are very suggestive of spindling-sprout. He attributes this condition to the abnormally dry weather in the summer of 1911 which caused potatoes to ripen prematurely and sprout prematurely, thereby making it necessary to remove the sprouts several times previous to planting. This so weakened the tubers that they were unable to produce strong sprouts at planting time.

Certainly, the trouble on Long Island can not be satisfactorily explained in this way, because sprouts had been removed from the tubers but once previous to planting. Moreover, according to Appleman,[6] "Removing the sprouts repeatedly does not seem to weaken the buds for seed; the eighth crop of sprouts from the same buds was just as vigorous as the first."

[4] The potato trouble illustrated by C. L. Fitch in one of his publications (Identification of potato varieties. Iowa State College of Agriculture and Mechanic Arts. Extension Bul. 20 : 5, fig. 1. 1914) is not *filosité* as we understand it, but rather one form of what the Germans call "Durchwachsen." (See Sorauer. Handbuch der Pflanzenkrankheiten, Dritte Aufl., 1:162. 1909.)

[5] Appel, [O]. Über Kartoffelkrankheiten. Vortrag gehalten im Klub bayerischer Landwirte zu München. Separatabdruck aus dem Bericht der General-Versammlung vom 13, 14 und 15 Januar 1913, p. 2.

[6] Appleman, C. O. Changes in Irish potatoes during storage. Md. Sta. Bul. 167:333. 1912.

According to Sorauer[7] *Fadenbildung* occurs abundantly only where light soil which heats easily has to undergo long periods of dry weather. This describes, exactly, the conditions on eastern Long Island in 1913. Sorauer's theory of the origin of *Fadenbildung* is as follows: "When the tubers, in immature condition, through forced ripening suffer a cessation of growth and are then harvested, the eyes have not yet attained their normal development. The shoots from these must, naturally, be weak. If such tubers are used for seed the following year under like culture these symptoms of weakness must gradually increase and lead to the result that, finally, only stems of the fineness of a thread are produced. Accordingly, the disease is the consequence of a continued cultural error, namely, an inadmissible shortening of the vegetative period."

The writers consider this theory untenable. It does not accord with known facts in regard to the behavior of immature seed potatoes. Some other factor besides the shortening of the vegetative period must enter into it. Immature tubers, grown in cool weather, are considered by some to be as good if not better than mature tubers for seed purposes.

Delacroix[8] regards *filosité* as a condition of degeneracy resulting from continued asexual propagation under unfavorable conditions. Excessive drought he considers a secondary factor.

Parisot,[9] on the other hand, advances an entirely different theory. He claims to have proven by means of experiments (the details of which are not given) that *filosité* proceeds from the intoxication of the tubers by the carbon dioxid gas resulting from their own respiration. After explaining how, in piles of potatoes, the quantity of carbon dioxid increases rapidly as the distance below the surface increases, he says: "It is easy to explain how it occurs that filosité is so common in the bottom of large piles, and the means of avoiding it."

It is well known that potato tubers are constantly taking up oxygen and giving off carbon dioxid; also, that, in the storage of seed potatoes, some provision should be made for ventilation; but the idea that lack of ventilation is a cause of spindling-sprout, we

[7] Sorauer, P. Handbuch der Pflanzenkrankheiten. Dritte Aufl. 1:159-161. 1909.
[8] Delacroix, G. Sur la "filosité" des pommes de terre. Extrait du *Jour. Agr.* [Paris]. Dec. 1903.
[9] Parisot, F. La filosité de la pomme de terre. Bul. Mens. Off. Renseig. Agr. [Paris]. 9:21-24. 1910.

cannot accept without more evidence. We have observed nothing which indicates that the deep piling of potatoes in storage has such an effect.

EXPERIMENTS WITH TUBERS IN HERMETICALLY SEALED JARS.

Along this line we have made several experiments with tubers in hermetically sealed jars. Large glass jars were filled with clean, dry tubers on which the sprouts were barely, if at all, started. The jars were then hermetically sealed with paraffin or sealing wax and placed in a darkened room at a temperature of 16° to 21° C. (60° to 70° F.). So long as they remained in the air-tight jars the tubers invariably refused to sprout while check tubers in unsealed jars sprouted freely. If removed within about ten days they afterwards sprouted, but a longer exposure in the jars resulted in the death and decay of the tubers. Whenever the tubers sprouted at all the sprouts were of normal size — there was no tendency toward the spindling-sprout condition. In one case tubers which had been in a sealed jar for nine days remained dormant for about ten days after removal and were thought to be incapable of sprouting, but sprouts of normal size finally appeared. Eleven of the tubers were planted whole. The plants were of normal size and appearance and gave a yield of twelve pounds which is a good crop considering the character of the soil in which the plants were grown.

Although it appears improbable that the widespread trouble with home-grown seed potatoes on Long Island in the spring of 1914 was due to faulty methods of storage, this phase of the subject requires further investigation.

OTHER DISEASES WITH SIMILAR SYMPTOMS.

It is quite possible that spindling, thread-like sprouts are not always due to the same cause; that is to say, there may be two or more distinct diseases having the spindling-sprout symptom in common. The existence of such widely different theories as to the origin of *filosité* and *Fadenbildung* suggests this, as do, also, the following observations of our own: Early in the spring of 1914 a farmer in Greene County sent us a quantity of tubers some of which were affected with one of the stem-end-browning diseases. There was a distinct browning in the vascular region at the stem end of the

tuber. Diligent search by cultural and microscopical methods failed to discover any organism and the cause of the discoloration was not determined. The point of present interest is that after the tubers commenced to sprout the diseased ones could be readily distinguished from the healthy ones by the difference in the size of their sprouts. The diseased tubers, though of fair size and normal appearance externally, produced very slender sprouts. While not so small as the sprouts on Long Island tubers affected with spindling-sprout, they were plainly sub-normal. Twenty-five affected tubers were planted. The resultant plants had slender stalks and never attained normal size, but were entirely normal in other respects. The yield of tubers was small, but none of them showed any indication of stem-end browning. This disease is certainly different from the true spindling-sprout disease, yet affected tubers show a sprout condition which is similar to that which characterizes spindling-sprout.[10]

That the production of spindling sprouts may be one of the symptoms of yet another disease is shown by the following observations: In 1913 the senior author grew in his garden at Geneva a short row of potatoes of the variety Ionia. The plants were not watched for signs of disease, but it is known that they grew to large size and were still partly green when frost came about the middle of September. After digging, the tubers were stored in a cool cellar until planting time the following spring. On May 26, 1914, some of the tubers were used for planting about one hundred hills. By the time the larger plants were a foot high a marked unevenness in the size of the plants was noticeable and this became more conspicuous as the season advanced. About thirty of the plants were pronounced dwarfs with the leaves curled downward and the bushy appearance characteristic of the curly-dwarf disease. These plants died prematurely. The tubers which they bore were small, longer than normal and somewhat pointed at both ends, but not affected with stem-end browning. About thirty other plants grew thriftily, became large and yielded well.

[10] The "spindle disease (*Persola tomentosum*)" briefly discussed and illustrated in *Jour. Dept. Agr. West. Aust.* 17 (1908), No. 5, p. 857, pl. 1, was probably of a similar nature. This idea is suggested by the statement that the diseased condition of the tubers might be detected by cutting them at the "tail end." The use of *Persola tomentosum* as if it were the name of the causal organism appears to be an attempt at a joke, though it may have been intended for *Periola tomentosa* Fr., a fungus which occurs on potato tubers. No organism bearing the name *Persola tomentosum* is known to the writers.

The remaining forty plants were intermediate in character. Judging from their size and the downward curling of their leaves they were all more or less diseased, yet they yielded fairly well.

At digging time a few of the best and a few of the poorest hills were set aside for experiments in 1915. The remainder were thrown into a box and stored in a furnace-heated cellar. By the middle of March, 1915, the tubers in the box bore sprouts one to three inches in length. Some were normally robust, some moderately slender and many others extremely slender — typical spindling sprouts. (See plates II and III.) Occasionally, large tubers showed robust sprouts at the bud end and slender sprouts growing from eyes near the stem end.

IS SPINDLING-SPROUT AN HEREDITARY DISEASE?

Orton's[11] statement that "this constitutional defect [spindling-sprout?] is not cured by restoration to a northern environment," suggests that spindling-sprout is an hereditary disease. Long Island potato growers who have planted the progeny of spindling-sprout tubers inform us that the results are always unsatisfactory. They say that the trouble seems to increase from year to year. Definite information based on actual experiments seems to be lacking.

However, Emerson's[12] experiments in Nebraska show that by growing seed potatoes under a mulch of straw it is possible not only to prevent the deterioration which occurs in a hot, dry climate under ordinary methods of culture, but actually to bring back to productiveness a stock which has become badly run down through cultivation. Whether spindling sprout was involved in these experiments is not known. No mention is made of the symptoms presented by the run-down potatoes.[13]

[11] Orton, W. A. *Loc. cit.*

[12] Emerson, R. A. Home mulched vs. northern seed potatoes for eastern Nebraska. Nebr. Sta. Bul. 146. 1914.

[13] Replying to our inquiry on this point Prof. Emerson writes as follows: "I made no careful comparative observations on the sprouts of mulched and of cultivated tubers, nor did I compare directly the diameters of the plants as they stood in the field. I did, however, make a general observation that the cultivated tubers produced weaker plants than mulched tubers. My general impression of the differences between the plants of the two lots is not that the stems of one were decidedly more spindling than those of the other. The plants of the one lot were merely somewhat smaller, and if there was a difference in diameter of stems relative to height of the plant, it was not sufficient to impress me. The differences which I have noted were usually more pronounced early in the season than when the plants had nearly completed their growth."

PLATE II.—SPINDLING SPROUTS ON TUBERS FROM CURLY-DWARF PLANTS; VARIETY, IONIA. Compare with Plate III. (Natural size.)

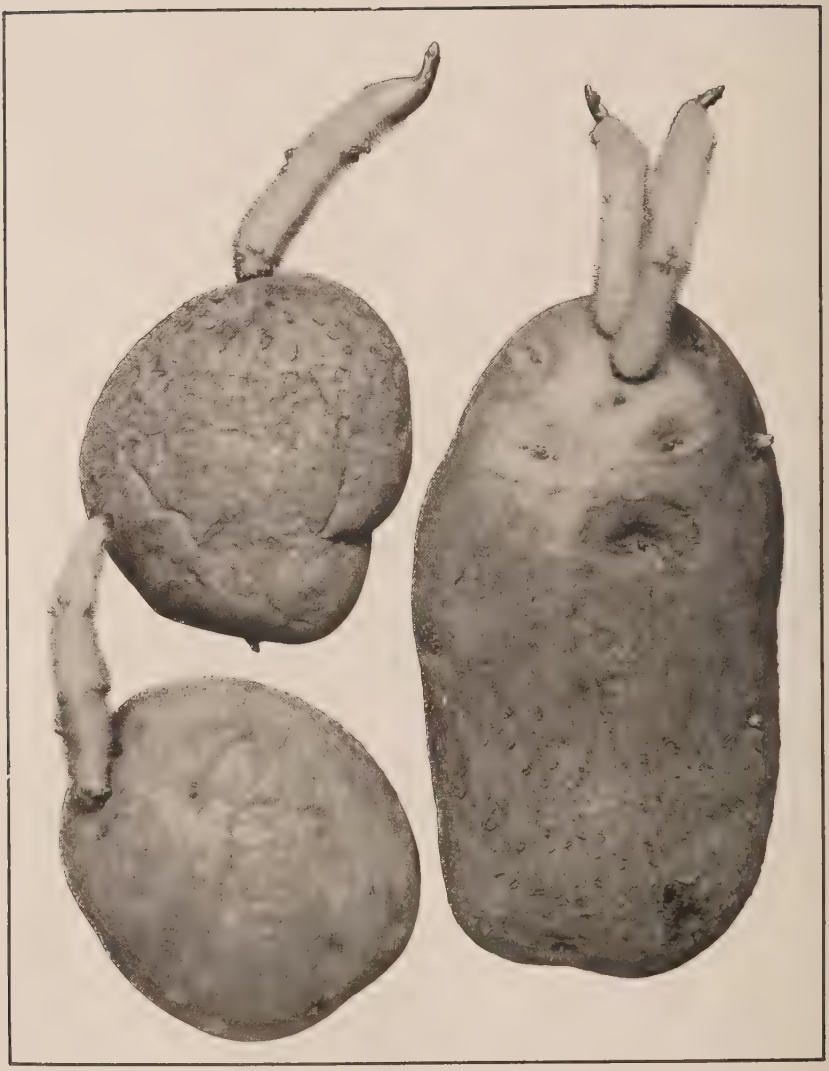

PLATE III.— NORMAL SPROUTING OF IONIA POTATO TUBERS.
(Natural size.)

The following experiment made by the writers shows that the progeny of tubers affected with spindling-sprout do not invariably produce spindling sprouts: Eight Geneva-grown tubers, four of which were the progeny of typical spindling-sprout tubers and the other four the progeny of normal-sprouted tubers, were induced to sprout in February by putting them in a dark place under a bench in a greenhouse. All of the tubers but one produced normally robust sprouts. The exception was a tuber of spindling-sprout parentage. The sprouts on this were abnormally slender though not as slender as those on the parent tuber.

MEANS OF AVOIDING TROUBLE WITH SPINDLING-SPROUT.

Since spindling-sprout occurs chiefly in southern-grown seed one way of avoiding it is to use only northern-grown seed. Another way is to make a sprouting test. Long Island farmers who contemplate using home-grown seed should always make a sprouting test before planting. This is especially important after a very dry season. From four to eight weeks before planting time a small quantity of the potatoes should be put in a warm, dark place to sprout. If all of the tubers produce strong sprouts it is safe to assume that the seed is suitable for planting; but if some of the tubers produce spindling-sprouts, the seed is not fit to plant. It seems as if this should be a simple method of avoiding trouble with spindling-sprout.